The Latest GPCP Monthly and Daily Products and High-Latitude Considerations

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Also see:

36th Hydrol. Poster 734: Advancing GPCP Products to Version 3.2
G. Huffman, A. Behrangi, R. F. Adler, D. T. Bolvin, E. J. Nelkin, and J. J. Wang

Trenberth Symposium 4.4: Global Precipitation Means and Variations: The New Version of GPCP.
Adler, Gu, Huffman, Behrangi, Bolvin, Wang, Nelkin

Introduction

- The Global Precipitation Climatology Project (GPCP) product is one of the few state-of-the-art "global" long-term precipitation products (~ 4 decades) that is well maintained and widely used as an observational reference by international communities. GPCP products have been used in more than 5000 journal papers.
- Large uncertainties have been reported in high latitude for GPCP, especially over the oceans (Adler et al. 2012)
- In light of new estimates (TRMM, GPM, CloudSat, GRACE), it was recognized that GPCP update is needed.
- Users require higher resolution data:

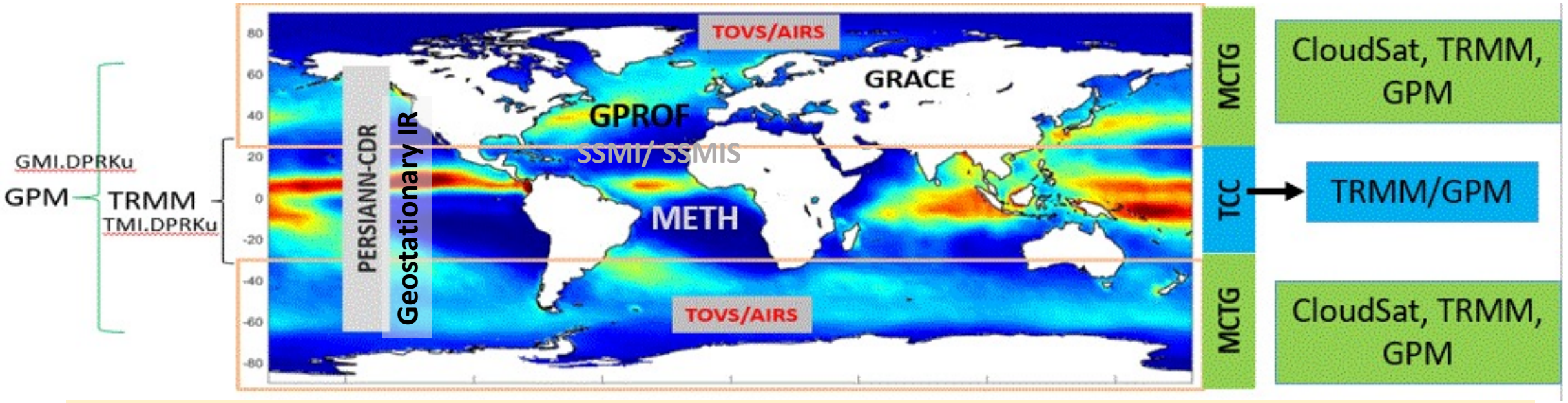
- GPCP V2.3 is currently monthly at 2.5°x2.5° since 1979 ,
- GPCP 1DD V1.3 is currently daily at 1.0°x1.0° since 1996.

The new version of GPCP (V3.2) brings in new satellite observations and retrievals to guide the development of GPCP and to produce GPCP with higher spatial resolution than before

Changes from monthly GPCP Version 2.3 to GPCP Version 3.2

- Upgraded geosynchronous infrared (GEO-IR) brightness temperature datasets, including expansion from the latitude band 40°N-S to 60°N-S.
- Upgraded algorithms for passive microwave (PMW) data (GPROF 2010 and METH for tropics and GPROF 2010 for extra tropics; still only used for month-to-month calibration). For IR PERSIANN CDR is used.
- Used IR-only Advanced Infrared Sounder (AIRS-IR) estimates throughout, replacing the heterogeneous AIRS-microwave (AIRS-MW)/ AIRS-IR record.
- Replaced calibrations of (heterogeneous) AIRS to TOVS by calibration of TOVS to AIRS-IR
- Scaled GPROF/METH-adjusted PERSIANN-CDR by Tropical Combined Climatology (TCC) over the 20°N-S band, the Merged CloudSat-TRMM-GPM (MCTG) outside the latitude band 35°N-S, and a smooth transition from TCC to MCTG over the latitude band 25°-35° N/S.
- Scaled all Television InfraRed Operational Satellite (TIROS) Operational Vertical Sounder (TOVS) and AIRS-IR monthly estimates by MCTG globally.
- Added three new fields to the output file: *1. probability of liquid-phase precipitation, 2. Gauge Relative Weighting*, and *3. Quality Index(QI).*
- Extended the period of record through December 2020, so it covers 1983-2020.
- Replaced Legates with Fuchs gauge undercatch correction method over northern Asia and Eurasia (poleward of 45°N) based on several published analysis with insights from GRACE, CloudSat, streamflow observations, and water vapor convergence analysis

Main satellites used

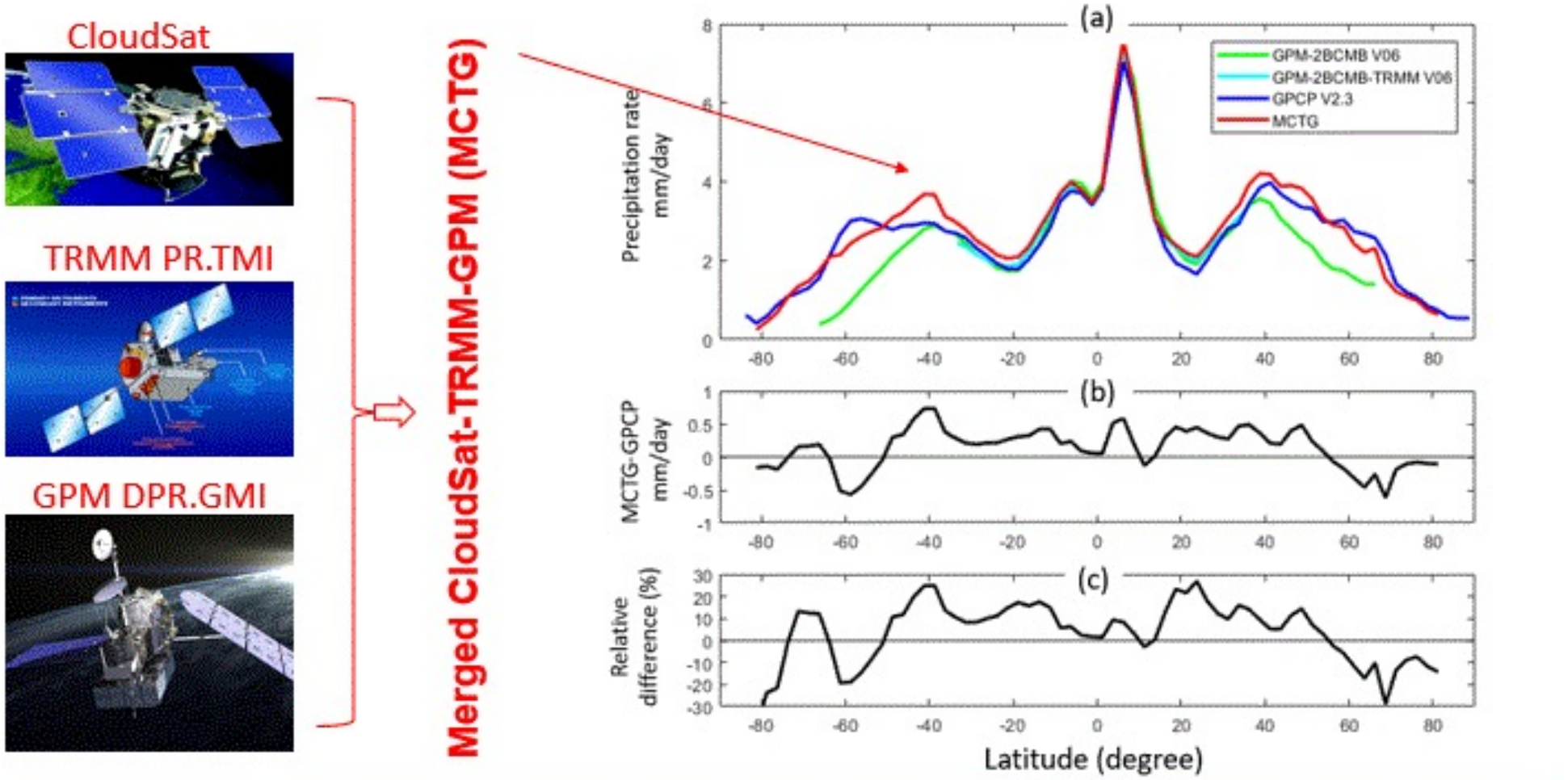


- 58ºN-S
  - 1992-present: PERSIANN CDR histogram-adjusted using GPROF (SSMI /SSMIS) at the 3-hourly scale, calibrated to monthly METH (SSMI/SSMIS), then calibrated with TCC/MCTG climatology blend
  - 1983-1991: PERSIANN CDR adjusted using monthly climatological (1993-2008) GPROF relationship
- higher latitudes
  - calibrated TOVS/AIRS-IR (globally) adjusted to the MCTG

TCC: TRMM Composite Climatology – Adler et al. (Univ. of Maryland)

MCTG: Merged CloudSat/TRMM/GPM climatology – Behrangi et al. (Univ. of Arizona)

MCTG development



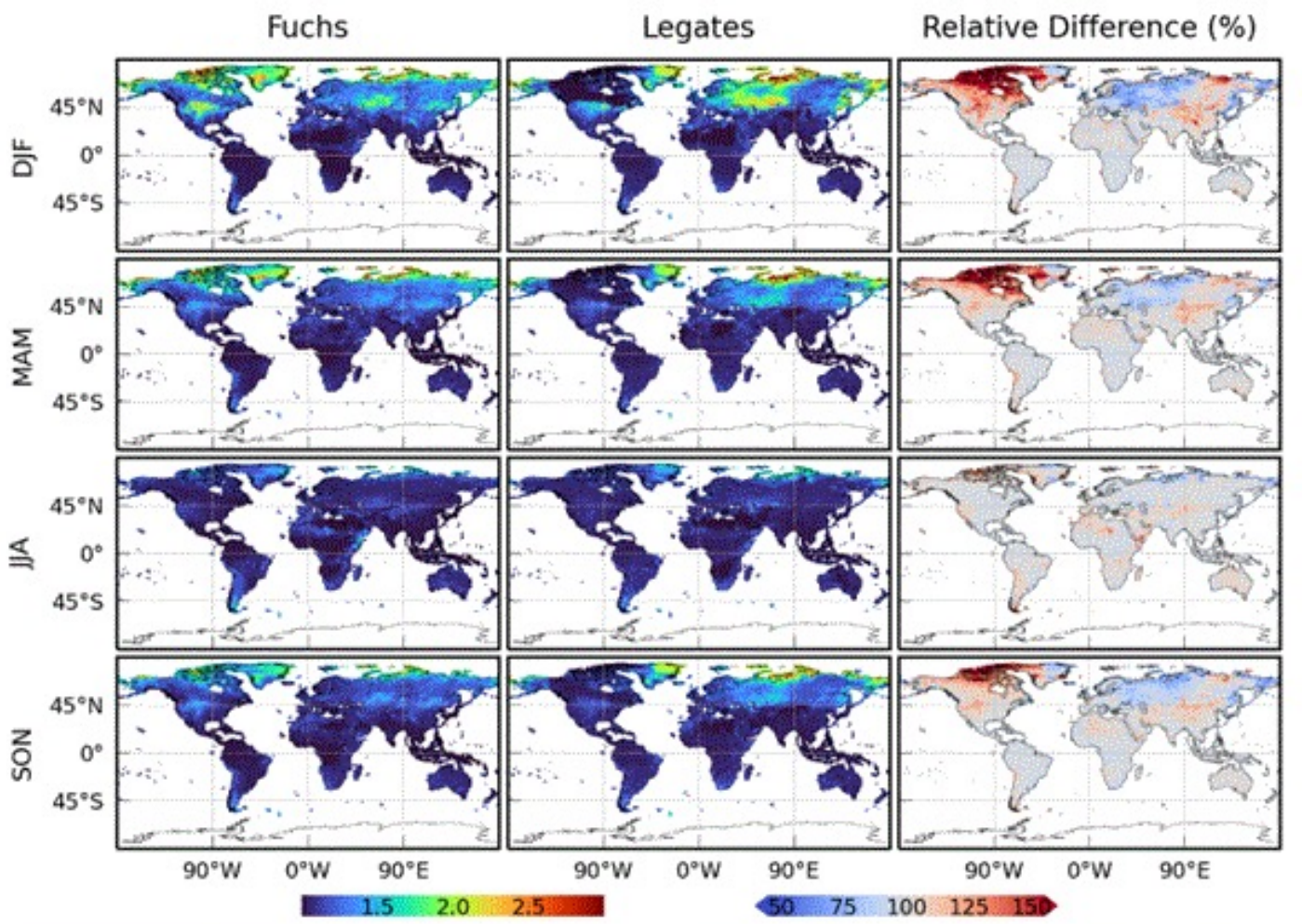
MCTG is used to guide the development of GPCP V3.1 and GPCP V3.2 over the extra tropics

Behrangi and Song (2020), *Environmental Research Letters*

Gauge undercatch correction:

- Two methods are popular for global application: Fuchs (2001) and Legates and Willmott (1990).

- Major differences exist between the two methods that seems seasonal dependent can exceed 100%.
- The correction factors for gauge undercatch are generally bigger for snow than rainfall.



Seasonal maps of CF-F (left column) and CF-L (middle column), and relative differences between the two (i.e., $\frac{100 \times CF-F}{CF-L}$, right column) calculated from monthly CF-L and 38 years (1982-2019) of monthly CF-Fs. From top to bottom, rows show winter, spring, summer, and fall, respectively. The maps are produced at 1-degree spatial resolution.

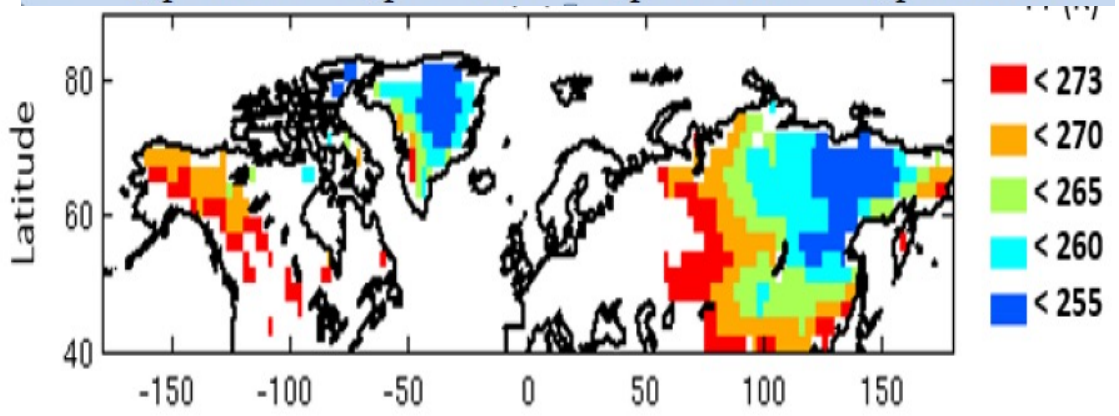
CF-L is correction factor based on Legates and Willmott (1990)
CF-F is correction factor based on Fuchs et al. (2001)

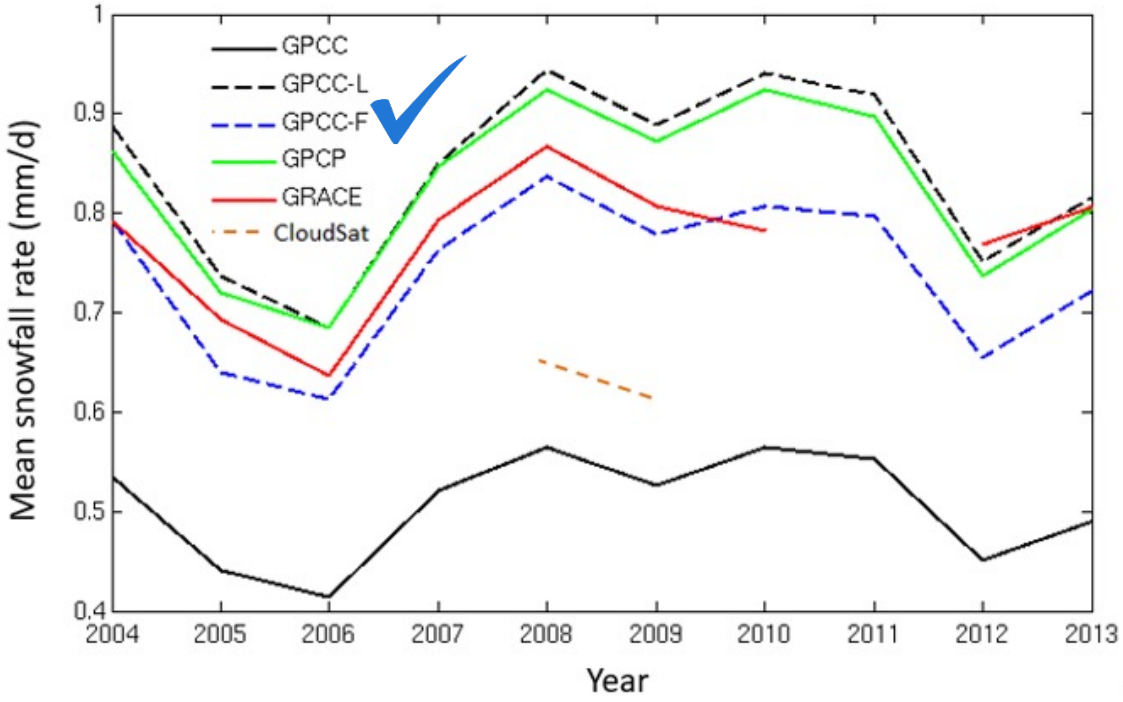
Gauge undercatch correction: insights from GRACE analysis

- Using GRACE, it turns out Fuchs undercatch corrections matches the water budget analysis better than Legates correction, more clearly over Eurasia.

- This is also consistent with other studies using streamflow measurements and water vapor convergence (Behrangi et al. 2014; 2019).

$$\Delta S = \int_{t_1}^{t_2} P(t)dt - \int_{t_1}^{t_2} ET(t)dt - \int_{t_1}^{t_2} Sub(t)dt - \int_{t_1}^{t_2} Q_{net}(t)dt$$





Behrangi et al. (J Climate 2018)

GPCP V3.2 monthly product data fields

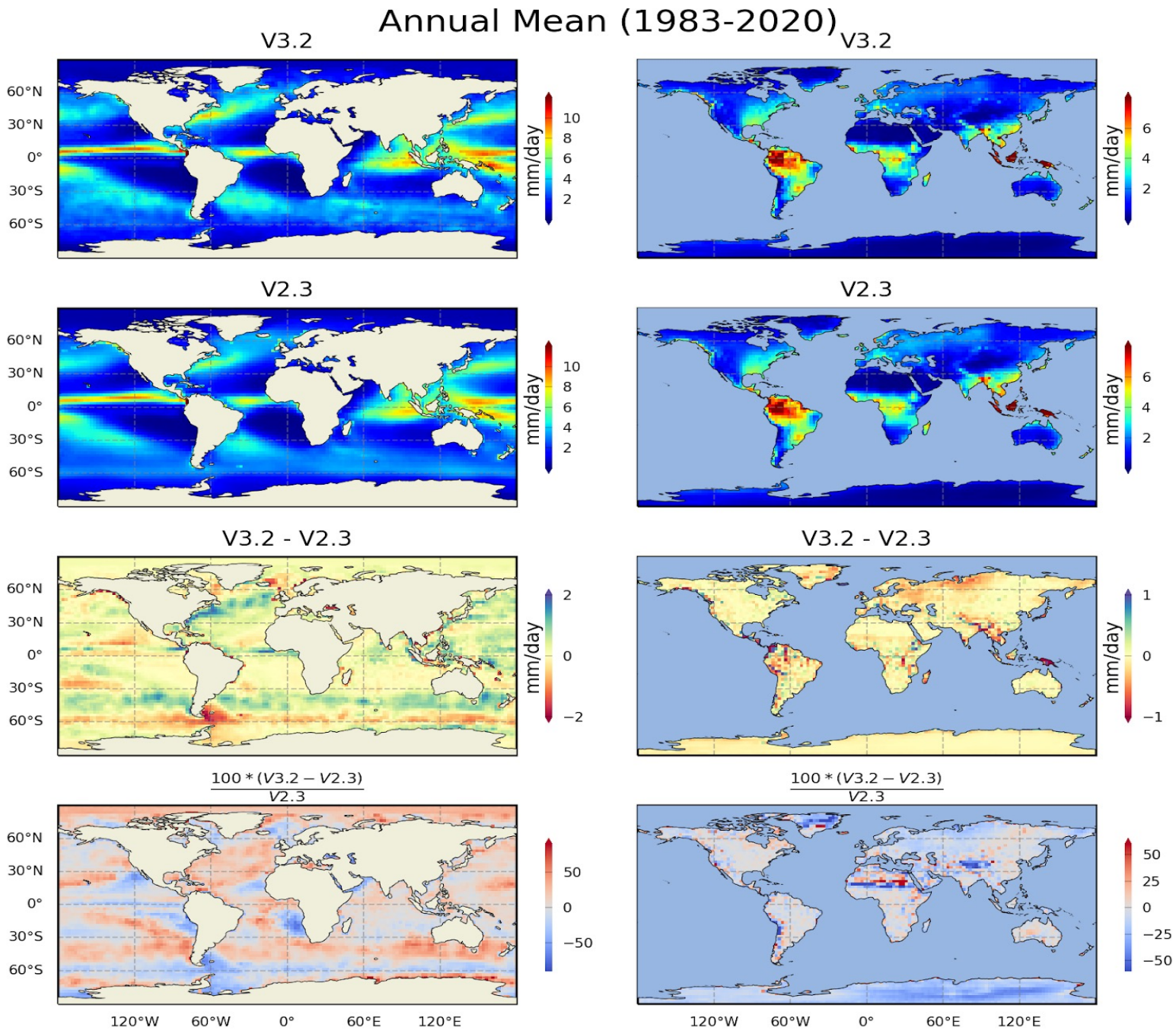
Data Field Name	Description	Units
latitude	latitude of the center of the grid element	degrees_north
longitude	longitude of the center of the grid element	degrees_east
time	begin date and time of the data	minutes since 1979-01-01 00:00:00
sat_gauge_precip	combined satellite-gauge precipitation estimate	mm/day
sat_gauge_error	combined satellite-gauge precipitation random error estimate	mm/day
satellite_precip	satellite-only precipitation estimate	mm/day
satellite source	source of the contributing satellite estimate *	index values
gauge_precip	wind-loss adjusted gauge precipitation	mm/day
probability_liquid_precip	probability of liquid phase precipitation	percent
gauge_relative_weight	relative weighting of gauges in sat_gauge_precip	percent
quality index	equivalent number of gauges	unitless

* The satellite source field has the index values 0 = PMW-adj. IR, 2 = blend of PMW-adj. IR and TOVS/AIRS, 4 = TOVS/AIRS.

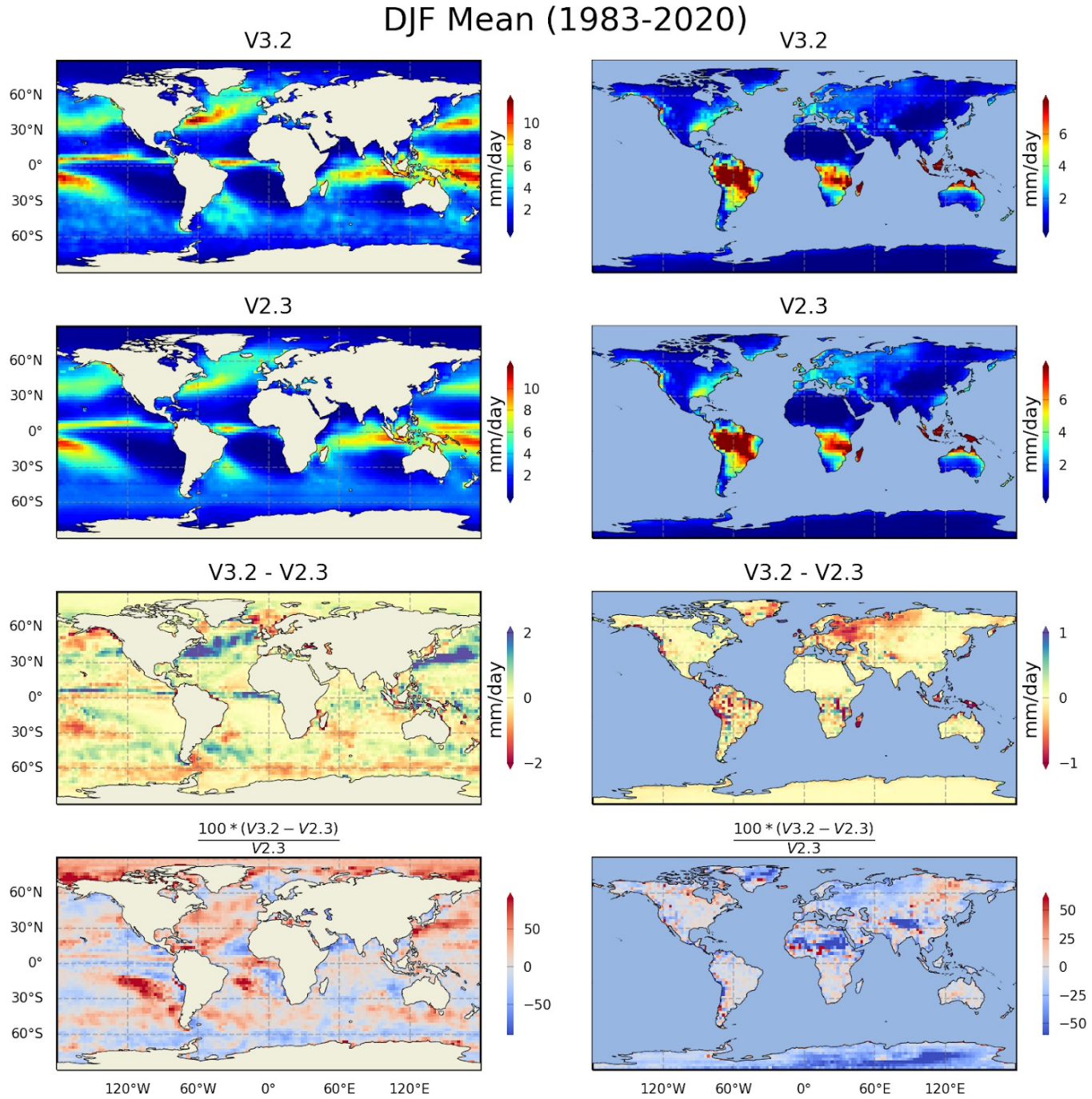
Results/Comparison 1/5

Spatial maps: For comparison V3.2 is mapped from 0.5º to 2.5º

- ❑ V3.2 tends to be higher over oceans
- ❑ largest increases in storm tracks
- ❑ decrease around 60ºS in 3.2 improves a perceived 2.3 issue
- ❑ increase in polar regions driven by CloudSat (in MCTG)
- ❑ Gauges tend to dominate land areas in both V2.3 and V3.2
- ❑ The impact of using Fuchs gauge undercatch correction (in V3.2 over Northern Asia poleward of 45º) instead of Legates correction is considerable reduction of precipitation amount over Eurasia. This is consistent with previous studies based on GRACE and water vapor convergence



- The reduction of precipitation due to use of Fuchs correction (used in V3.2) instead of Legates (used in V2.3) is larger in the cold season



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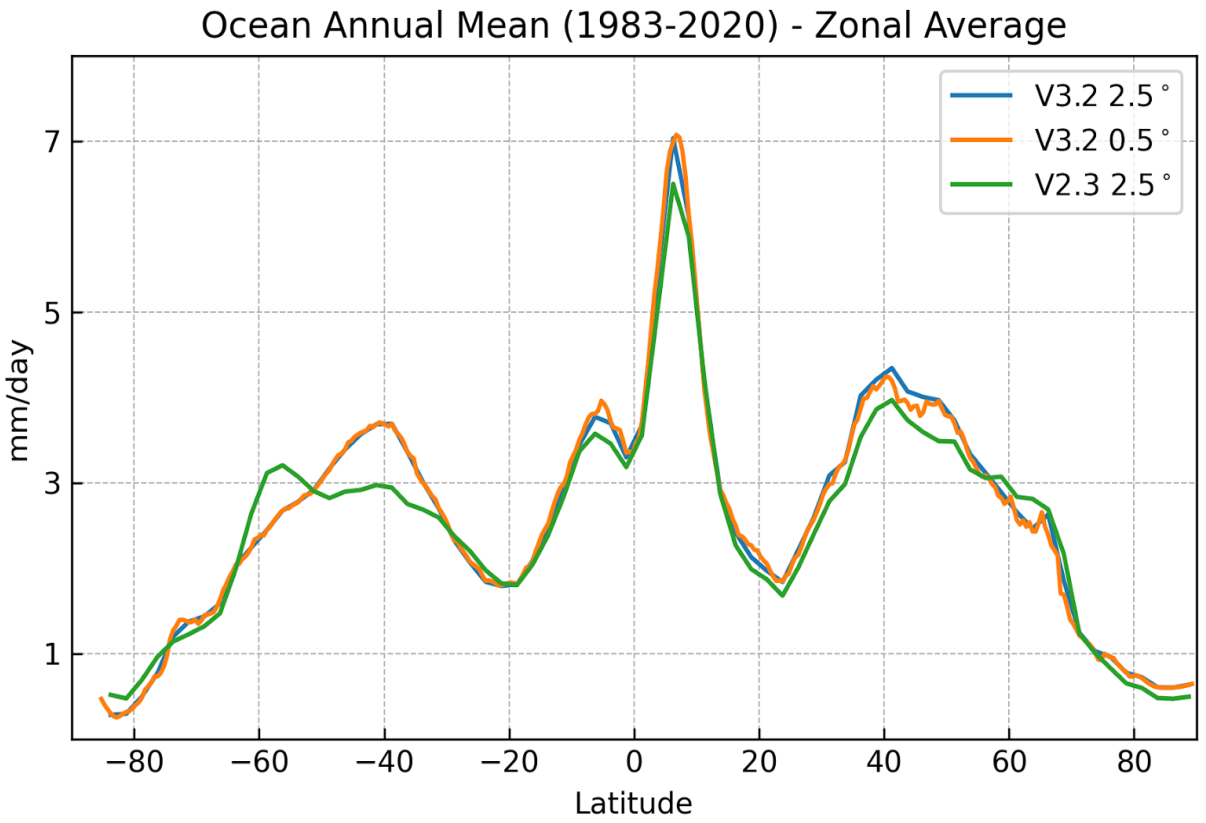
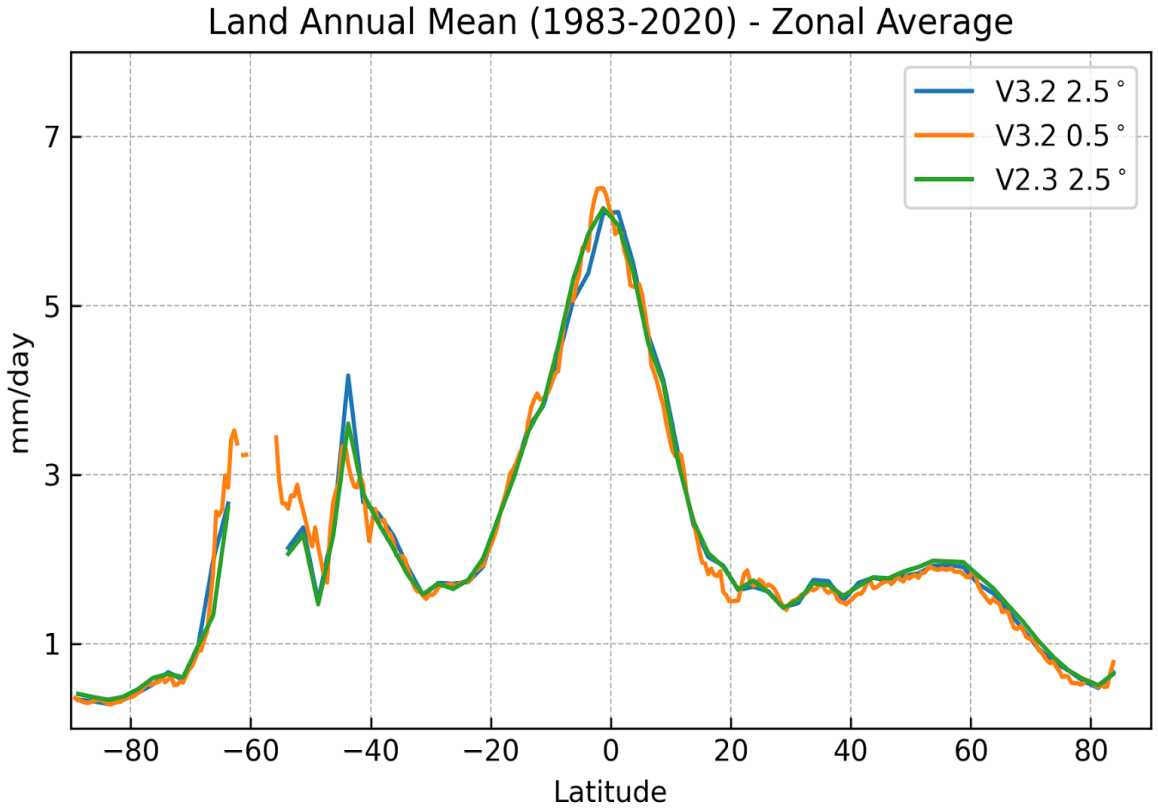
(University of Arizona)

Results/Comparison 2/5

The zonal profiles:

- The biggest difference between V3.2 and V2.3 is in the Southern Ocean considered an improvement in 3.2
- Changes over land are much smaller than over ocean between V3.2 and V2.3





Results/Comparison 3/5

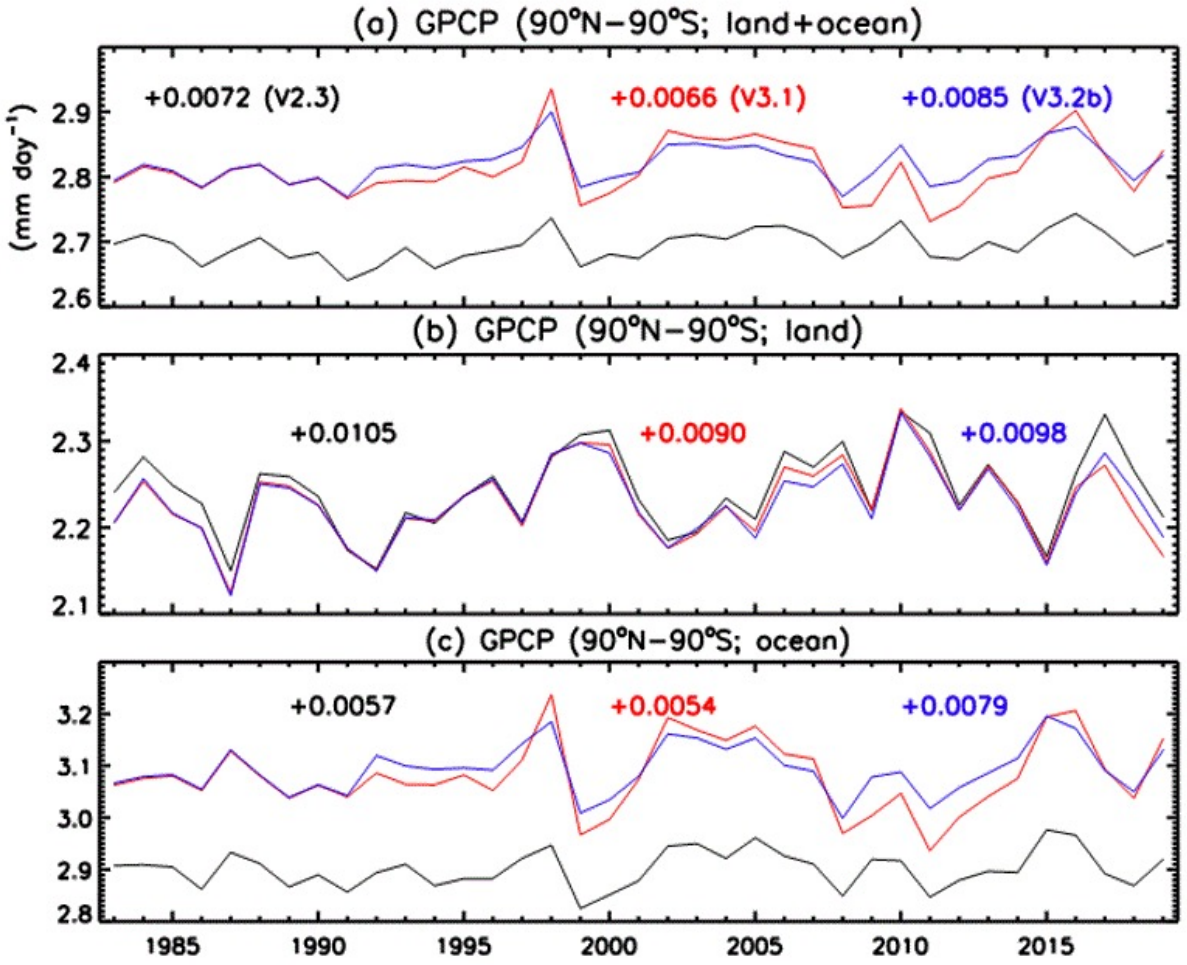
Mean precipitation: the calculations include cosine correction for area change at different latitudes

Comparison of V3.2 and V2.3 for mean precipitation rate (mm/day) (1983-2020)

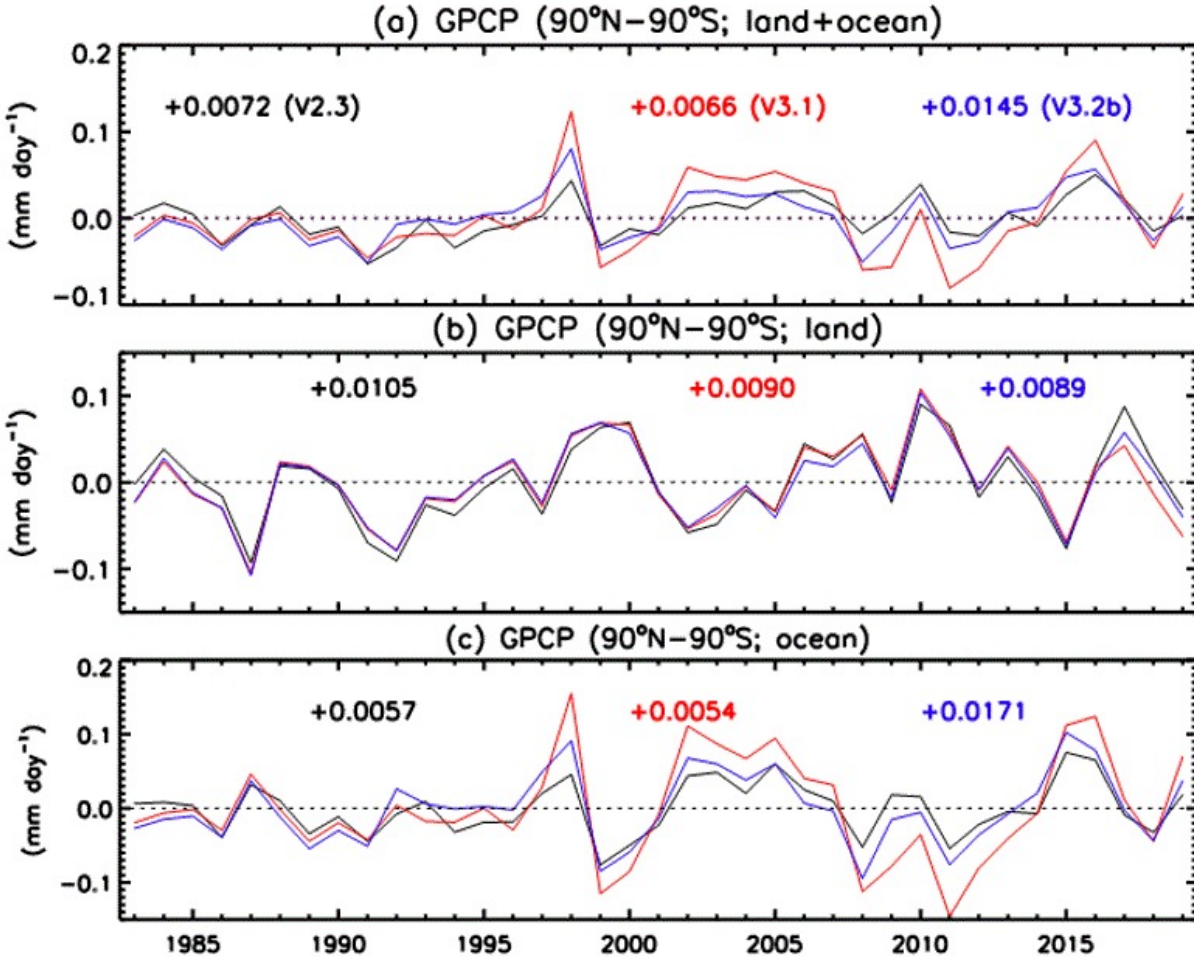
	Ocean			Land			Global		
GPCP	V3.2	V2.3	% change compared to V2.3	V3.2	V2.3	% change compared to V2.3	V3.2	V2.3	% change compared to V2.3
25°N-25°S	3.30	3.17	4.09	3.43	3.47	-0.99	3.33	3.25	2.62
60°N-60°S	3.22	3.04	5.90	2.53	2.54	-0.75	3.02	2.90	4.22
90°N-90°S	3.06	2.90	5.47	2.21	2.24	-1.04	2.79	2.69	3.76

Results/Comparison 4/5 (mean, trends, and inter-annual variation)

Global Annual Mean Precipitation



Global Annual Mean Anomalies

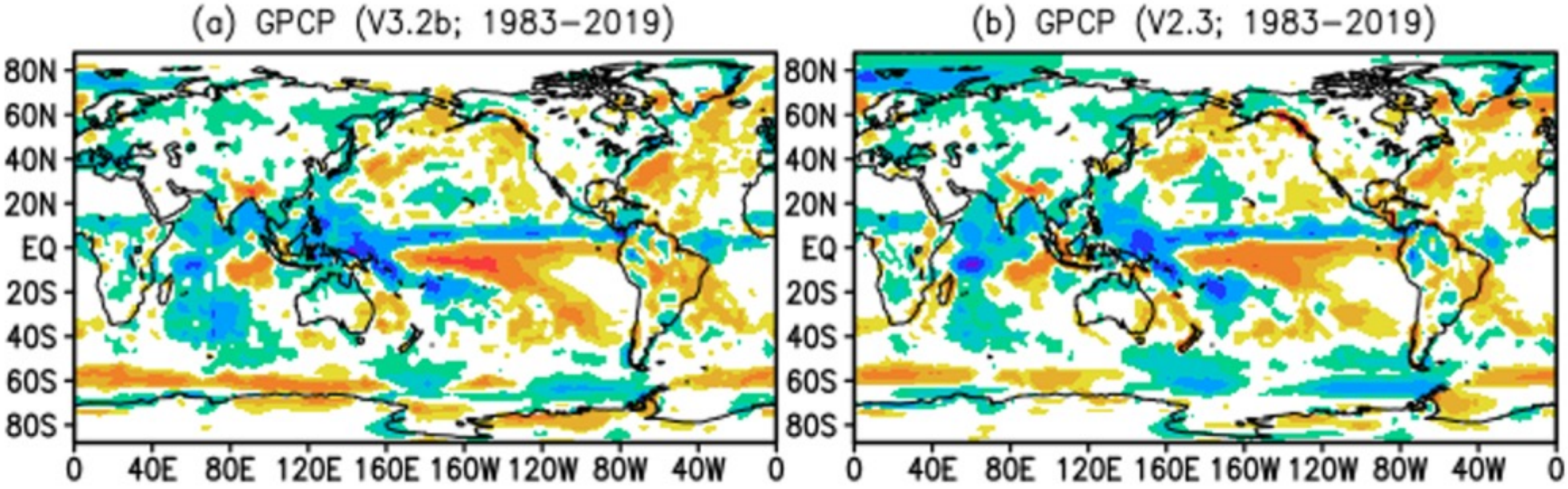


[Adler et al. ; UMD]

- **inter-annual variation in the tropics is governed by METH in both v3.2 and V2.3**
- **calibration by TCC and MCTG sets the mean increase in V3.2 relative to V2.3**

Results/Comparison 5/5

Trend Map



[Adler et al. ; UMD]

- **regional trends remain generally similar between V2.3 and V3.2**

GPCP V3.2 – Daily Product Approach

The inputs are:

- Integrated Multi-satellitE Retrievals for GPM (IMERG)
- TOVS, AIRS-IR daily: Susskind cloud volume
- GPCP V3.2 Monthly

Approach:

- average IMERG (originally 0.1°, ½ hr) up to 0.5° daily
- histogram-calibrate TOVS, AIRS-IR to IMERG
- use IMERG in the band 55° N-S and IMERG-calibrated TOVS/AIRS at higher latitudes
  - this is done for simplicity; future versions will use IMERG at all latitudes
- "feather" the IMERG-AIRS difference just outside 55° to reduce seams
- scale the Daily to (approximately) sum to the Monthly product

Data Fields- June 2000-Dec 2020 currently (global 0.5° x 0.5° lat./lon. Grid)
satellite precipitation estimate (mm/d) & probability of liquid-phase precipitation (%)

Summary

GPCP Version 3.2 is designed for

- inclusion of new satellite products (e.g., CloudSat, TRMM, GPM, and insights from GRACE) this results in major updates.
- higher user expectations (e.g., higher spatial resolution and more output fields)
- upgrades in dataset formats and archiving
- continued CDR standards

Monthly and daily datasets are ready to be posted at GES DISC

- monthly (going back to 1983), daily (going back to june 2000), both at 0.5^{o} resolution
- by design, submonthly (approximately) add up to the monthly values
- documentation is being finalized
- GPCP V3.2 products should be available in February 2022
- V3.2 monthly DOI: 10.5067/MEASURES/GPCP/DATA304
- V3.2 daily DOI: 10.5067/MEASURES/GPCP/DATA305

For questions:

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